

Aboveground net primary productivity and rainfall use efficiency of grassland on three soils after two years of exposure to a subambient to superambient CO₂ gradient.

Fay, P.A., H.W. Polley and V.L. Jin

Atmospheric CO₂ concentrations (CA) have increased by about 100 $\mu\text{L L}^{-1}$ over the last 250 years to ~ 380 $\mu\text{L L}^{-1}$, the highest values in the last half-million years, and CA is expected to continue to increase to greater than 500 $\mu\text{L L}^{-1}$ by 2100. CO₂ enrichment has been shown to affect many ecosystem processes, but experiments typically examine only two or a few levels of CA, and are typically constrained to one soil type. However, soil hydrologic properties differ across the landscape. Therefore, variation in the impacts of increasing CA on ecosystem function on different soil types must be understood to model and forecast ecosystem function under future CA and climate scenarios. Here we evaluate the aboveground net primary productivity (ANPP) of grassland plots receiving equal rainfall inputs (from irrigation) and exposed to a continuous gradient (250 to 500 $\mu\text{L L}^{-1}$) of CA in the Lysimeter CO₂ Gradient Experiment in central Texas, USA. Sixty intact soil monoliths (1 m² x 1.5 m deep) taken from three soil types (Austin silty clay, Bastrop sandy loam, Houston clay) and planted to seven native tallgrass prairie grasses and forbs were exposed to the CA gradient beginning in 2006. Aboveground net primary productivity was assessed by end of season (November) harvest of each species in each monolith. Total ANPP of all species was 35 to 50% greater on Bastrop and Houston soils compared to Austin soils in both years ($p < 0.0001$), suggesting greater rainfall use efficiency on these soils despite lower water holding capacity of the Bastrop soils. On the Austin soil, grasses produced 2.7 fold more biomass than forbs, compared to only 30 % more grass biomass on the Houston soil ($p = 0.002$), suggesting that grass dominance of community and ecosystem processes differed strongly among the soils. Total ANPP was strongly responsive to the CA gradient, with mean ANPP increasing from 260 g m⁻² at 250 $\mu\text{L L}^{-1}$ CA to 455 g m⁻² at 500 $\mu\text{L L}^{-1}$ ($p < 0.0001$), suggesting greater overall rainfall use efficiency with increased CA. Individual species showed varying responses among soils to the CA gradient ($p < 0.0001$). Biomass of the grasses {*Sorghastrum nutans*} and {*Schizachyrium scoparium*} and the forb {*Solidago canadensis*} strongly increased with increasing CA, with {*S. nutans*} responding more strongly on Bastrop and Houston soils ($p = 0.053$), indicating that increased greater rainfall use efficiency at high CA on these productive soils was associated with increased dominance by these species. In contrast, the grass {*Bouteloua curtipendula*} decreased in biomass with increasing CA, especially on Austin and Bastrop soils. The least productive species were the grass {*Tridens albescens*}, the legume {*Desmanthus illinoensis*}, and the forb {*Salvia azurea*}, and these showed no detectable response to CA. No species switched the sign of its response to CA among the soils. Thus, four of the seven species determined the ANPP and rainfall use efficiency responses to CA among the three soils. Interactions between soils and CA have important consequences for the productivity, rainfall use efficiency, and species composition of grassland under future atmospheric CO₂ concentrations.